HYDROCARBON GAS IN SURFACE SEDIMENTS OF THE CHUKCHI SEA

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INTRODUCTION

This geochemical study is part of a U.S. Geological Survey investigation in the Chukchi Sea in 1984 on the NOAA Ship SURVEYOR (Phillips et al, this report). During August 26 to Sept. 17, 1984, 40 box cores, 2 gravity cores and 4 dredge samples were collected in the shelf sediments of the Chukchi Sea. Of these, nineteen box cores and one gravity core were sampled for hydrocarbon gas analysis. Gss sample sites are illustrated in Figure 1. Specifically, the hydrocarbon gases examined were methane (Cl), ethane (C2), ethene (C2=), propane (C3), propene (C3=), isobutane (iC4) and n-butane (n-C4). The main objective was to sample localities where previous geophysical surveys indicated the possibility of gassy sediments and to ascertain the composition and origin of these gases.

METHODS

The box cores were subsampled for hydrocarbon gas analysis using a steel cylinder (diameter = 7.5 cm). The total length of box core sediment ranged from 18 cm to 56 cm. One gravity core was taken whose total length was 69 cm. A 10 cm section of sediment was removed from the top of the box core (0-10 cm) and from the bottom if possible. One sample (10 cm) was taken from the bottom portion of the gravity core. Each sample was immediately extruded into a can (approximately one liter volume) equipped with two septa covered holes near the top. Seawater was added to the can and 100 ml of this water was removed to establish a headspace before the can was sealed with a double-friction seal lid. Seawater samples were also canned periodically to monitor the composition of the water added to the sediment-filled cans. All cans were turned upside down and frozen until analysis in the shore-based laboratory. The frozen cans were brought to room temperature and shaken to extract the gases from the sediment into the air headspace. About 5 ml of this headspace gas was removed through the septa covered ports with a gas tight syringe. Exactly 1 ml of this mixture was injected into the gas chromatography equipped with both flame-ionization and thermal conductivity detectors. The gas chromatography was calibrated with a standard mixture of hydrocarbon gas. Calculations of gas concentrations were made by integrating the areas or measuring heights of the hydrocarbon peaks on the chromatograms. An average composition of the seawater sample headspace that would have contributed to the sediment sample analysis was subtracted from each analysis. Partition coefficients used to correct for differences in gas volubility are as follows: Cl = 0.8; C2, C3, iC4, nC4 = 0.7; C2=, C3= = 0.6. Concentrations are reported as nl/l wet sediment. Results are semi-quantitative but can be compared because all samples were processed in the same manner.

RESULTS

The concentration of hydrocarbon gases recovered from the 19 box cores and one gravity core are reported in Table 1. Hydrocarbon gases were present in all the samples analyzed. Cl is the most abundant hydrocarbon gas, ranging in concentration from 690 to 22,000 nl/l wet sediment. Box core 33 is the sample with the highest concentration of methane. The other hydrocarbon gases were present in much lower concentrations and when detected, ranged in concentration from 4 to 39o nl/l wet sediment. In general, the concentration of ethane is slightly greater than propane which is slightly greater than the butane (iC4 plus nC4) concentration. The alkenes C2= and C3= are in the same range of concentration as C2 and C3, although the concentration of C2= was greater than the concentration of C2 in a majority of the samples, while the concentration of C3 exceeds the concentration of C3= in a majority of the samples.

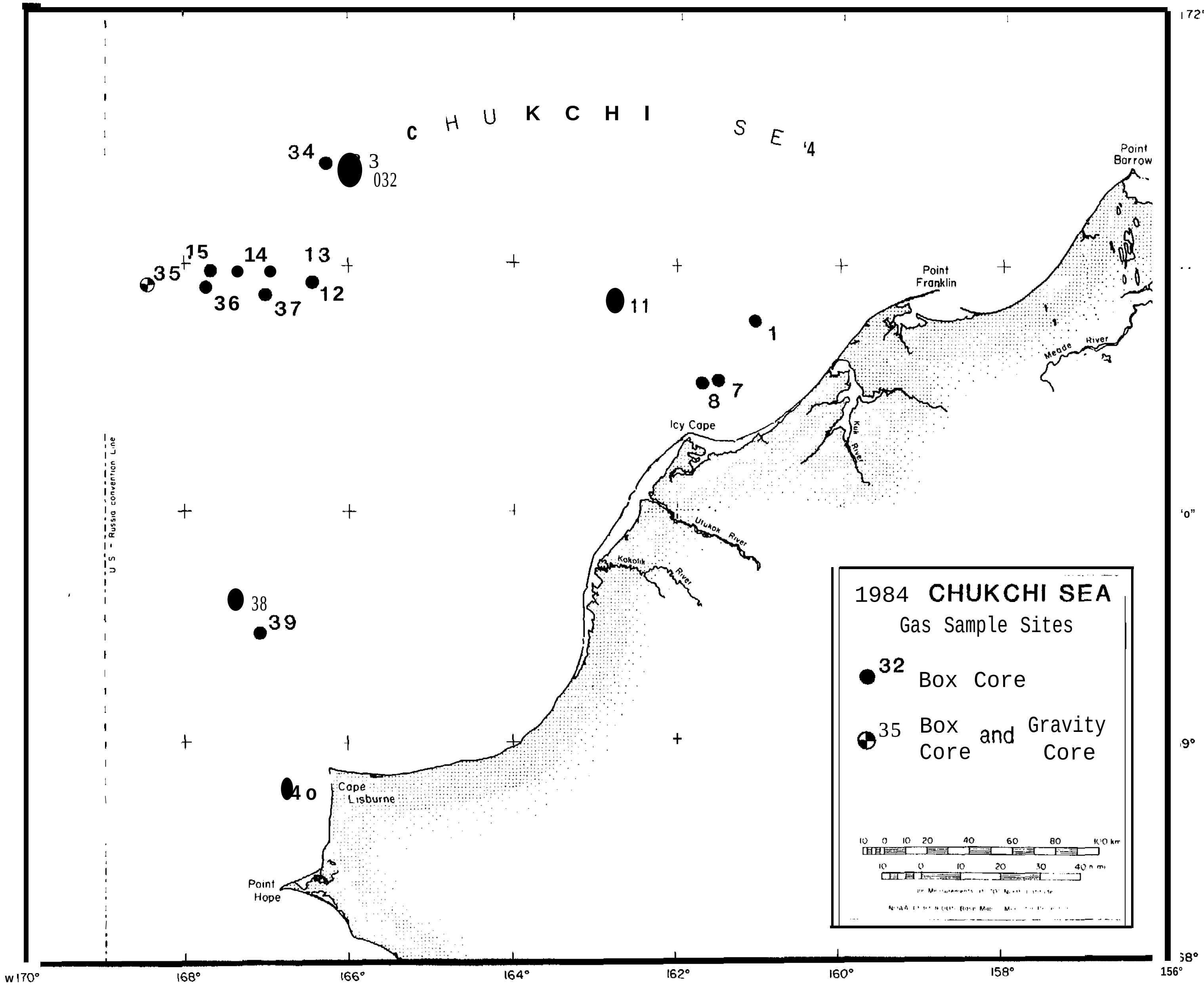

Figure 1. Location of hydrocarbon gas sampling sites in the Chukchi Sea,

DISCUSSION

A **1982** geophysical survey by the U.S. Geological Survey in the Chukchi Sea (Phillips and Reiss, 1984) revealed the occurrence of acoustically impenetrable zones in the surface sediments. The 1984 geophysical survey revealed a similar phenomena. Figures 1 and Appendix D (Phillips et al, this report) illustrate the extent of occurence of these zones and demonstrate the alternating zones of acoustically penetrable and impenetrable sediments observed in one geophysical transect (line 44). One possible explanation for this phenomena is the presence of interstitial gas bubbles in the sediment, as demonstrated by Schubel (1974). Box 33, where the highest concentration of methane was observed, was taken on a line 44, however, the amount observed is well below the concentration of methane that is indicative of saturation (about 40 ml of Cl per liter of seawater according to Yamamoto et al., 1976). There are several possible explanations for this observation: (1) the geophysical anomaly may not be do to gassy sediments (2) the geophysical anomaly may be due to gassy sediments, but an impervious sediment layer is preventing the diffusion and/or migration of the gas to the surface sediments sampled (3) the sampling station may have been outside the zone of acoustically impenetrable sediments. The hydrocarbon concentrations observed in surface sediments of the Chukchi Sea are in the same range of concentrations observed in for example, the shelf environment of the Bering Sea (Kvenvolden and Redden, 1980). The source of this "background" concentration of hydrocarbon gases likely results from in situ biological and /or very early diagenetic processes (Claypool and Kvenvolden, 1983).

CONCLUSIONS

Light hydrocarbons Cl, C2, C2=, C3, C3=, iC4, and nC4 are present in low concentrations in surface sediments of the shelf in the Chukchi Sea and likely result from biological and/or very early diagenetic processes. If the geophysical anomalies are due to gas-charged sediment, the inability to recover samples with high gas concentrations may result from the presence of an impervious layer preventing the diffusion and/or migration of the gss to the surface sediments sampled or the "gassy" sediments may be spotty in distribution, and therefore a more detailed sampling program would have to be pursued in order to recover samples with high gas concentrations.

REFERENCES

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Table 1. Hydrocarbon Gas Concentrations in Near-Surface Sediments of the Chukchi Sea,

Station & Int. (cm)	Water Depth (m)	cl	C2	C2=	C3	C3=	ic4	nC4	Location Latitude	Longitude
		nanoliters of gas / liter wet sediment								
Box 0010-10	44	320d '	330	350	240	170	23	59	70 " 47.6' N	161' 07.7'W
Box 0070-10	29	2200	130	120	59	. 60	14	26	70 " 33.1' N	161 " 38.9' W
Box 00814-24	25	9400	53	83	31	49	8	20	70 " 32.6' N	161 " 47.0' w
Box 0110-10	42	700	170	280	91	73	8	26	70 " 63.0' N	162" 51.7' W
Box 01120-30		1400	100	280	77	73	10	20		
Box 0120-10	42	3300	220	270	150	70	18	41	70 " 56.0' N	166 " 20.4' W
Box 012 41-s1		2100	72	250	72	74	n.d.	21		
Box 0130-10	46	690	160	280	92	71	9	26	70 " 57.3' N	166 " 56.9' W
Box 0140-10	46	000	220	250	92	58	7	21	70 • 68.6' N	167 • 23.8' W
Box 01438-48		2700	110	300	100	87	14	26		
Box 0150-10	44	2000	260	300	130	91	13	38	70 " 68.8' N	167- 44.4' W
Box 01518-28		7200	210	350	160	100	22	46		
Box 0160-10	50	2000	130	330	100	92	10	14	70 " 28.3' N	166- 57.2" W
Box 01626-35		4500	130	280	99	78	13	30		
Box 017 O-IO	43	3200	140	290	110	91	13	30	70. 24.6' N	166. 28.5' W
Box 01723-29		3400	190	380	130	100	15	33		
Box 0320-10	41	1200	170	280	110	69	10	34	71. 17.3' N	165 . 43.6' W
Box 032 40-50		4800	73	200	72	68	10	40		
Box 0330-10	42	2500	1s0	290	100	75	15	44	71 • 22.4* N	166 " 07.7' w
Box 03336-45		22000	77	260	75	95	10	30		
Box 0340-10	43	1400	150	240	04	90	17	62	71. 24.6' N	166 • 21.2' w
Box 03434-44		9900	80	190	86	66	8	24		
Box 0350-10	43	2200	150	200	95	68	8	33	70. 54.9' N	16S . 28.0' W
Box 03537-47		7900	84	280	83	89	8	23		
Gravity 03552-62		3600	72	260	74	86	9	36		
Box 0360-10	54	2900	200	240	120	71	4	37	70. 62.8' N	167" 46.9' W
Box 03046-66		4300	70	140	86	60	16	34		
Box 0370-10	46	4900	210	390	140	72	12	45	70. 50.4' N	167. 06.2' W
Box 03732-42		13000	92	280	130	91	14	21		
Box 0380-10	47	2600	130	260	110	76	17	57	69. 34.7* N	167 • 24.7' W
Box 03837-47		4000	160	300	120	120	18	44		
Box 0390-10	46	1200	160	260	110	75	13	52	69 • 20.6' N	167. 03.7' W
Box 03937-47		1800	85	290	94	78	12	39		
Box 0400-10	40	2600	150	210	110	63	16	51	68. 49.2' N	166. 44.7' W
Box 04019-29		8100	86	190	73	66	19	39		

n.d. = not detected